

Evaluation of peak or onset latency in the median-versus-ulnar digit four sensory comparison study for diagnosing carpal tunnel syndrome

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Abstract

Aim: Peak or onset latency difference of the median and ulnar nerves can be used in the median-versus-ulnar digit 4 sensory comparison study (MUD4CS) for electrodiagnosis of carpal tunnel syndrome (CTS). This study aimed to investigate the differences in results while using peak or onset latency difference.

Material and Methods: The hands of patients with clinical CTS diagnosis but normal median nerve conduction study (NCS) results were included retrospectively in this study. NCSs of the median and ulnar nerves with onset and peak latencies in MUD4CS were recorded. Onset and peak latency differences of the two nerves and also peak-onset latency difference of the median nerve in MUD4CS were calculated. The hands were divided into two groups according to MUD4CS findings: abnormal and normal. The hands in the abnormal group were also divided into peak and onset subgroups.

Results: A total of 277 hands were included in this study. Abnormal MUD4CS results were observed in 103 hands; 77 hands based on onset latency difference, and in 76 hands based on peak latency difference. Median sensory conduction velocity was slower and amplitude was smaller in the abnormal group than in the normal group ($p=0.003$, $p=0.027$ respectively). Median peak-onset latency difference was significantly greater in the peak subgroup than in the onset subgroup ($p=0.0001$).

Conclusion: It may be more useful to measure both peak and onset latency differences when diagnosing CTS because some cases may be overlooked by using a single latency difference.

Keywords: Carpal tunnel syndrome; electrodiagnosis; median; ulnar

INTRODUCTION

Carpal tunnel syndrome (CTS) is the most common reason for entrapment neuropathies. Diagnosis of CTS is primarily based on clinical evaluation (1,2). Electrodiagnostic tests confirm the clinical diagnosis and provide information regarding severity of the disease (3,4). Electrodiagnostic tests include sensorial and motor conduction studies of the median and ulnar nerves, and needle electromyography. Nerve conduction studies (NCSs) mostly yield abnormal results in patients with clinical CTS. If sensorial and motor conduction studies of the median nerve yield completely normal results, comparison studies of the median nerve with other adjacent nerves may also help in the electrophysiological diagnosis (5,6). The median-versus-ulnar digit 4 sensory comparison study (MUD4CS) is one of these studies. The medial and lateral half of the fourth

finger are innervated by the ulnar and median nerves, respectively. The latencies of the median and ulnar nerves can be compared by stimulating the nerves at equal distances to the fourth finger. The difference in the median and ulnar onset or peak latencies is then calculated. If the latency difference is longer than 0.5 ms, it can be defined as prolonged median latency in MUD4CS (7). Onset latency is mainly associated with the fastest conducting fibers in a nerve bundle (4). In the early stage of CTS, the fastest conducting nerve fibers (especially sensorial fibers) are more prone to be affected (8). Therefore, onset latency may be expected to be affected earlier than peak latency in comparison studies (2). However, it is not always easy to accurately measure the onset latency of sensory nerve action potentials (SNAP) because of stimulus artifacts. Generally, measurement of the peak latency of SNAP is easier than measurement of onset latency. That's why the

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difference in peak latency of SNAPs may be preferred frequently in comparison studies. On the other hand, the population of sensory nerve fibers represented by peak latency (in contrast to the onset latency) has not yet been identified (4).

There are some advantages and disadvantages of using the difference of peak or onset latency in comparison study, as mentioned above. It is important to decide whether to use peak or onset latency difference in comparison studies to confirm the diagnosis in patients who are clinically thought to have CTS but normal routine median NCSs. We performed this study to investigate whether there is any difference in the electrodiagnosis of CTS on using peak or onset latency difference in MUD4CS. Further, we investigated whether there is any difference in the electrophysiological parameters of the patients diagnosed with CTS based on peak or onset latency difference.

MATERIAL and METHODS

Study population

The medical records of the patients who were admitted to the electrodiagnosis laboratory with a preliminary diagnosis of CTS between 01/05/2015 and 31/03/2017 were retrospectively reviewed. Among them, patients with clinical CTS diagnosis but normal median motor and sensory NCS and MUD4CS results were assessed in the present study. This study was approved by the local ethics committee of Bakirkoy Dr. Sadi Konuk Training and Research Hospital, Bakirkoy, Istanbul, Turkey (2017/138).

Inclusion and exclusion criteria

The hands of patients with clinical CTS diagnosis but normal median motor and sensory NCS results, and also having MUD4CS for the symptomatic side, were included in the study. Patients whose complaints were consistent with CTS and who had detailed history and medical records were included in this study. According to previous studies, clinical CTS diagnosis was determined as hand paresthesias in the area innervated by the median nerve, and satisfying at least 2 of the following criteria: night paresthesias, relieved by shaking the hand and paresthesias increased by activities (2,9).

Patients who had any abnormality in the routine median and ulnar sensory-motor NCSs, any upper extremity nerve injury, polyneuropathy and radiculopathy, and those with incomplete data were excluded from this study. Further, the patients whose complaints were not consistent with CTS and whose medical records did not contain adequate clinical findings at the time of admission were not included in this study.

Data collection

Electrophysiological tests results were obtained from patients' records. Nihon Kohden (Tokyo, Japan) Neuropack with two channels was used to perform electrophysiological tests. The compound muscle

action potential (CMAP) was recorded using skin surface electrodes, and the amplitude of CMAP was measured from peak to peak; SNAP was recorded antidromically using ring electrodes, and the amplitude of SNAP was measured from onset to peak. Supramaximal electrical stimulation was performed in all NCSs.

In median motor NCS, the median nerve was stimulated at the wrist and antecubital site, and CMAPs were recorded from the abductor pollicis brevis muscle. In median sensory NCS, the median nerve was stimulated at the wrist, and SNAP was recorded from the second finger. Motor NCS of the ulnar nerve was performed on the abductor digiti minimi muscle by stimulating from the wrist and below the elbow. Sensory NCS of the ulnar nerve was recorded from the fifth finger by stimulating the wrist.

The MUD4CS was performed antidromically at 11–13 cm distance to the fourth finger, with supramaximal stimulation. If median-ulnar latency difference (median latency-ulnar latency) in the MUD4CS was >0.5 ms, it was considered to indicate prolonged median distal sensory latency or minimal CTS (10).

Data regarding age, sex, affected side, SNAP amplitude, sensory conduction velocity (CV), distal motor latency, distal CMAP amplitude, and motor CV of median and ulnar nerves were obtained from patients' records. The onset and peak latencies of the median and ulnar nerves in MUD4CS were recorded. The latency difference between the median and ulnar nerves in MUD4CS was calculated separately using onset and peak values of the two nerves. Further, the difference between peak and onset latencies of median SNAP in the MUD4CS was also calculated.

First, the hands were divided into two groups according to MUD4CS findings. A peak or onset latency difference >0.5 ms was defined as abnormal, and a difference ≤ 0.5 ms was defined as normal. Subsequently, the hands with abnormal findings were categorized into peak and onset subgroups. The peak subgroup was defined as abnormal based on peak latency difference, and had normal onset latency difference (Peak +/Onset-). Conversely, the onset subgroup was defined as abnormal based on onset latency difference, and had normal peak latency difference (Onset +/Peak-). The electrophysiological data were then compared between the two subgroups.

Statistical analyses

Statistical analysis was performed using the MedCalc software (version 16.2.1; MedCalc Software, Ostend, Belgium). Descriptive statistics (mean, standard deviation, median, frequency, ratio, and minimum and maximum values) were reported. Categorical variables were compared using chi-squared test. For comparison of quantitative data, normally distributed variables were compared between the two groups using Student's T-test, respectively. Results were evaluated at a significance level of $p < 0.05$.

RESULTS

In total, 277 hands of 215 patients met the inclusion criteria of this study. The mean patient age was 44.3 ± 11.8 years. On hundred ninety-one (88.8%) women and 24 (11.2%) men were included in the study. There were 145 (52.3%) right and 132 (47.7%) left hands.

There were 103 (37.2%) hands with abnormal MUD4CS based on the peak or onset latency difference; 174 (62.8%) hands had normal MUD4CS. The results of median NCSs for the hands with abnormal and normal MUD4CS

are shown in Table 1. Median nerve sensory CV was significantly slower and median SNAP was smaller in the abnormal group than in the normal group.

Forty-five hands (16.2%) had abnormal MUD4CS findings based on both peak and onset latency differences. There were 27 (9.7%) and 31 (11.2%) hands in the onset and peak subgroups, respectively. Abnormal findings were observed in 72 (26%) and 76 (27.4%) hands based on onset and peak latency differences, respectively.

Table 1. Median Nerve Conduction Studies In Patients With Abnormal And Normal Comparison Study

	Abnormal comparison study	Normal comparison study	p
Median nerve SNAP amplitude (mcV)	31.32 ± 19.39	35.79 ± 15.73	0.027*
Median nerve sensory conduction velocity (m/sec)	53.28 ± 2.31	54.21 ± 2.49	0.003*
Median nerve motor CMAP distal amplitude (mV)	15.3 ± 4.4	14.9 ± 4.2	0.62
Median nerve motor distal latency (sec)	3.22 ± 0.3	3.16 ± 0.3	0.37
Median nerve motor conduction velocity (m/sec)	57.2 ± 4.1	57.6 ± 4.2	0.69

Values were expressed as mean \pm standard deviation. SNAP: Sensory Nerve Action Potential. CMAP: Compound Muscle Action Potential.

*p<0.05. Student's T-Test

Table 2. Median Versus Ulnar Digit 4 Comparison Study of Peak and Onset Groups

	Peak Group N=31	Onset group N=27	p
Median sensory onset latency (msec)	2.6 ± 0.2	2.6 ± 0.25	0.462
Ulnar sensory onset latency (msec)	2.3 ± 0.2	2.0 ± 0.3	0.196
Median-ulnar onset latency difference (msec)	0.32 ± 0.12	0.60 ± 0.09	0.0001*
Median sensory peak latency (msec)	3.42 ± 0.23	3.18 ± 0.32	0.0011*
Ulnar sensory peak latency (msec)	2.82 ± 0.2	2.90 ± 0.3	0.3
Median-ulnar peak latency difference (msec)	0.60 ± 0.11	0.28 ± 0.11	0.001*
Median peak-onset difference (msec)	0.82 ± 0.19	0.54 ± 0.16	0.0001*

Values were expressed as mean \pm standard deviation. * p<0.05. Student's T-Test

Table 3. Median Nerve Conduction Studies In Peak And Onset Groups

	Peak Group N=31	Onset group N=27	p
Median SNAP amplitude (mcV)	35.99 ± 12.86	37.42 ± 13.72	0.68
Median sensory conduction velocity (m/sec)	52.5 ± 2.4	53.3 ± 2.3	0.86
Median motor CMAP distal amplitude (mV)	14.6 ± 3.6	16.3 ± 4.6	0.2
Median motor CMAP distal latency (milisec)	3.16 ± 0.33	3.29 ± 0.29	0.12
Median motor conduction velocity (m/sec)	56.6 ± 3.9	57.6 ± 5	0.2

Values were expressed as mean \pm standard deviation. SNAP: Sensory Nerve Action Potential. CMAP: Compound Muscle Action Potential.

*p<0.05. Student's T-Test

The MUD4CS findings for onset and peak subgroups are shown in Table 2. Peak-onset latency difference for the median nerve was significantly higher in the peak subgroup ($p=0.0001$). The results of median sensory and motor NCSs for the onset and peak subgroups are shown in Table 3. There was no significant difference between the onset and peak subgroups in the parameters of median motor and sensory NCSs.

DISCUSSION

In this study, we observed abnormal MUD4CS findings in 37.2% of the symptomatic hands of patients with clinical CTS diagnosis but normal median sensory and motor NCS results. A previous study has shown that MUD4CS has a 85.7% sensitivity in patients with clinical CTS diagnosis (11). On the other hand, 15% asymptomatic healthy controls also showed abnormal MUD4CS findings in another study (12). To our knowledge, there are few studies investigating the patients with clinical CTS diagnosis but normal routine median NCS results. Lee et al. (11) showed that short-distance NCSs across the wrist had a sensitivity of 37.3% and median-ulnar or median-radial comparison studies had a sensitivity of 66.1% in patients with clinical CTS diagnosis but normal median NCS results. This percentage is more than that obtained in our study, but we only assessed the results of median-ulnar comparison study. On the other hand, Demirci et al. (13) showed that segmental study of the median nerve had a higher sensitivity than other comparative studies. Chang et al. (14) reported abnormalities in MUD4CS 51.9% and in median-radial digit I comparison study 53.7% of patients with clinical CTS diagnosis but normal NCSs. In another study, patients with clinical CTS diagnosis but normal NCSs had 44% abnormalities in MUD4CS and in median-radial digit I comparison study (15).

When we used only peak latency difference in MUD4CS, 9.7% of the hands (27 hands in the onset subgroup) were found to have normal findings. On the other hand, when we used only onset latency difference, 11.2% of the hands (31 hands in the peak subgroup) were found to have normal MUD4CS findings. There are some advantages and disadvantages of using peak or onset latency difference. Although onset latency represents the CV of the fastest nerve fibers, it is occasionally difficult to place the onset latency precisely. Measuring the peak latency is easier than measuring the onset latency, but the population of nerves fibers contributing to the peak latency has not been clearly identified and is assumed to be comprised of fibers with medium range velocity (4). Further, a study investigating the reliability of NCS in workers has shown that the inter- and intra-examiner variation was minimal for median sensory peak latency compared with onset latency and median sensory onset and peak latencies were measured from the index finger (16). Studies investigating peak or onset latencies in the context of electrodiagnosis of CTS have yielded conflicting results. Prakash et al. (17) reported that median sensory peak latency from the index

finger measurement was the most sensitive method for electrodiagnosis of CTS. On the other hand, Lew et al. (8) showed that measurement of median sensory onset latency, especially in short segment transcarpal NCS, was the most sensitive method for CTS diagnosis. Kasius et al. (2) stated that peak and onset latencies have a good agreement and also recommended the use of peak latency for uncontrollable situations in comparison studies. According to our study results, there was no significant difference in diagnosis of CTS using onset or peak latency difference in MUD4CS. This is likely due to the fact that onset latency is more affected by stimulus artifact despite showing the fastest conducting nerve fibers, or that peak latency is less affected by stimulus artifact, but cannot fully show fastest conducting nerve fibers. Similar to this study's results, Kasius et al. (2) reported that onset and peak latencies used in electrodiagnosis of CTS had a good overall agreement.

Abnormal comparison study using only onset latency were detected in 25.9% of the hands of patients with clinical CTS diagnosis but normal median NCSs, and in 27.4% of the same population using only peak latency. When we considered abnormal study as a criteria at least one of peak or onset latency difference in MUD4CS, the probability of abnormal study in patients with clinical CTS diagnosis but normal median NCSs was found to be 37.2%. In this study, when we evaluated patients based on a single latency (only onset or only peak) difference, we were unable to diagnose some cases in MUD4CS.

Further, median sensory CV was significantly slower and median sensory amplitude was significantly smaller in the abnormal group than in the normal group. This was expected because median sensory NCS is more sensitive than other electrophysiologic parameters in the diagnosis of CTS (18).

This study also showed that median peak-onset latency difference in MUD4CS was significantly greater in the peak subgroup than in the onset subgroup. The peak-onset latency difference can be considered a measure of temporal dispersion (17,19). Therefore, temporal dispersion was observed more prominently in the peak subgroup than in the onset subgroup. Harmon et al. (19) showed that the time difference between onset and negative peak latencies of median transcarpal mixed nerve action potential was greater in patients with median neuropathy at the wrist. Although, in this study, the median nerve peak-onset latency difference was greater in the abnormal group, the difference between the abnormal and normal groups was not statistically significant. Prakash et al. (17) have reported that temporal dispersion may not be the major factor affecting median nerve conduction, especially in early stages of CTS, and latency determination may be a more sensitive parameter.

The electrophysiologic diagnosis of CTS in patients with normal median NCSs may occasionally be difficult. We evaluated median peak or onset latencies

for the electrodiagnosis of this patient group using MUD4CS. This study is different from previous studies because it evaluates the use of peak or onset latency in the aforementioned group of patients, who are more difficult to diagnose (2,8,17) This study compared the electrophysiologic results of the patients in the peak and onset subgroups, which, to our knowledge, has not been performed previously. Further, this study provides significant information regarding the diagnosis of borderline cases of CTS.

LIMITATIONS

There are some limitations of the study. First, the retrospective design of the study is a limitation. Second, in this study there was no healthy control group because of the retrospective design. Also, peak or onset latencies could be recorded by different examiners and so inter-rater differences could be evaluated, this is our third limitation. To show the segmental deceleration with palmar stimulation in median sensory study could provide more accurate information for CTS electrodiagnosis, but this was another limitation of this study

Future prospective studies investigating the relationship between peak and onset latencies will be beneficial for electrodiagnosis of CTS.

CONCLUSION

MUD4CS may significantly contribute to the electrophysiological diagnosis of patients with clinical CTS but normal median NCS results. Further, separate measurements of peak and onset latencies contribute to the diagnosis of CTS to similar extent, but using both of them is more likely to increase the possibility of diagnosing CTS in borderline cases.

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